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| DICKSTEIN SHAPIRO MORIN & OSHINSKY LLP | | | KIELIN, ERIK J | |
| 2101 L Street, NW | | | ART UNIT | |
| Washington, DC 20037 | | | PAPER NUMBER | |
| | | | 2813 | |

DATE MAILED: 11/24/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/912,558

Applicant(s)

WEIMER ET AL.

Examiner

Erik Kielin

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION:

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 28 September 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 13,14,16,17 and 42 is/are pending in the application.
- 4a) Of the above claim(s) none is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 13,14,16,17 and 42 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 21 September 2004 has been entered.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

3. Claims 13, 14, 16, and 17 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

Claim 13 requires the pressure in the chamber to be "held at about atmospheric pressure." First nowhere in the specification is it stated that the pressure is "held at about atmospheric pressure." Second and more importantly, this limitation is not enabled because the specification fails to indicate how the wet oxidation would be carried out using *in situ* reaction of hydrogen and oxygen at a pressure of about 1 atmosphere. The pressure of about 1 atmosphere **cannot** be

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maintained because there will necessarily be an explosion/detonation under the conditions presently disclosed. Rationale follows.

Given the claimed ratio of hydrogen to oxygen claimed to be 0.1 to 0.8 (that is the equivalent of 90 mol% O₂ in H₂ down to 10 mol% O₂ in H₂) and, as stated in the **specification at p. 8, lines 13-25**, that the ratio of steam to other gases is preferably 0.1 to 0.5 when such H₂ - O₂ mixture is used. Given the stoichiometry of the reaction between hydrogen and oxygen to form water: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, the concentration of hydrogen must be 0.1 or 10% (or 76 Torr at the claimed 1 atmosphere [760Torr] of pressure) relative to the other gases, in order to produce steam in a ratio of 0.1 relative to the other gases. The explosion concentration limits for hydrogen in air are 4.1% to 74.2%. (See Appendix A: obtained from <http://toxnet.nlm.nih.gov/cgi-bin/sis/search> which has the explosion limits for hydrogen in air.) Accordingly, there will **necessarily be an explosion** in the entire disclosed preferred range of 0.1 to 0.5 steam to other gases, disclosed in the instant specification. Fig. 7 of Miner shows that the detonation of hydrogen with oxygen **increases** the pressure. In the examples shown in Fig. 7, shows that 10% hydrogen (the 90% oxygen in the horizontal axis) only 15 Torr lead to an increase in pressure of 0.5 atm (380 Torr) that is a 380/15-fold or about 25-fold increase in pressure. Accordingly, the pressure presently claimed would far exceed 1 atmosphere.

Further in this regard, the instant specification at p. 9, lines 2-5 teaches away from such high pressures when H₂ and O₂ mixtures are used to generate the steam, stating,

“In general, the pressure can be at about atmospheric pressure, although if the H₂ and O₂ gases are combined in the chamber 50, then **the pressure should be kept lower, for example, around 1 millitorr.**”
(Emphasis added.)

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This pressure is 0.001 Torr. It begs the question as to why, now Applicant would claim that the pressure should be 760 Torr (1 atm), or 760,000 times the pressure indicated in the specification.

Still further in this regard, given the above indicated stoichiometry in the reaction between hydrogen and oxygen to produce water, 3 molecules combine to form two which necessarily reduces the pressure. This combined with the additional fact that the specification fails to address this and how the wet oxidation could be held at atmospheric pressure and teaches away from atmospheric pressure use if hydrogen and oxygen are reacted *in situ*, leads to the overwhelming lack of enablement of this feature and lack of written description. One of ordinary skill could simply not perform the method as claimed in claim 13 given the original disclosure.

Accordingly claim 13 is not enabled because specification fails to provide conditions capable of using an explosive mixture of H₂ and O₂ gases that could somehow be maintained at 1 atmosphere of pressure, given the above evidence.

The remaining claims are rejected for depending from the above rejected claims.

It is noted that this same rejection was applied to claim 42 of the instant application in the Office action filed 12 March 2004. It is unclear why Applicant would attempt to reintroduce this limitation into claim 13 after having removed the limitation from claim 42 for lack of enablement.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person

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having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

5. Claims 13 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 5,891,809 (**Chau et al.**) in view of **Van Zant**, Microchip Fabrication, 4th ed. McGraw-Hill: New York, 2000, pp. 163-164.

Regarding independent claim 13, **Chau** discloses a method of forming a gate dielectric layer on a substrate comprising the steps of

depositing a dielectric film **115**, **505** over an active region of a semiconductor substrate **500** to form part of a gate of a transistor (Figs. 1, 2, and 5; paragraph bridging cols. 3-4);

subjecting the dielectric film **505** to a densifying treatment **120** to stabilize said dielectric film by heating the semiconductor substrate, said densification and stabilization results from replacement of residual chlorine by oxygen (Figs. 1, 2, and 5; col. 4, lines 42-52); and

subjecting the stabilized dielectric film **505** to a wet oxidation with steam process **125** in a rapid thermal process chamber (because the processes are fast, the furnace is a "rapid thermal process chamber") to raise the oxygen content of said dielectric film, provided by heating a mixture of hydrogen and oxygen gases at a temperature greater than about 450 °C, in one embodiment to 750 °C and the H₂ to O₂ ratio is 2/5, which falls within the claimed H₂ to O₂ ratio of 0.1 to 0.8 (Figs. 1, 2, and 5; paragraph bridging cols. 4 and 5).

Chau is silent to the pressure used during the oxidation. **Van Zant** teaches that atmospheric pressure can be used for wet oxidation of silicon (pp. 163-164 --especially Fig. 7.15). It would have been obvious for one of ordinary skill in the art, at the time of the invention to use atmospheric pressure as the pressure for the wet oxidation in **Chau** because **Chau** is silent to the pressure such that one of ordinary skill would use pressures known for oxidation of

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silicon, such at those pressures taught to be notoriously well known in **Van Zant**. Further in this regard, it has been held that

“Normally, it is to be expected that a change in temperature, or in concentration, or in both, would be an unpatentable modification. Under some circumstances, however, changes such as these may impart patentability to a process if the particular ranges claimed produce a new and unexpected result which is different in kind and not merely degree from the results of the prior art... such ranges are termed ‘critical ranges’ and the applicant has the burden of proving such criticality More particularly, where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.” *In re Aller* 105 USPQ233, 255 (CCPA 1955).

See also *In re Waite* 77 USPQ 586 (CCPA 1948); *In re Scherl* 70 USPQ 204 (CCPA 1946); *In re Irmischer* 66 USPQ 314 (CCPA 1945); *In re Norman* 66 USPQ 308 (CCPA 1945); *In re Swenson* 56 USPQ 372 (CCPA 1942); *In re Sold* 25 USPQ 433 (CCPA 1935); *In re Dreyfus* 24 USPQ 52 (CCPA 1934). In the instant case, the instant specification provides no evidence of criticality to the pressure at which the wet oxidation is carried out since 1 milliTorr and 760 Torr are both taught as useful pressures.

Regarding claim 14, in addition to the exemplary 750 °C wet oxidation temperature, **Chau** indicates that the time depends upon both temperature and desired thickness of the oxide wherein examples of 13, 5.5 and 3 minutes are given (paragraph bridging cols. 4-5). Although **Chau** does not teach 20 to 60 seconds, the choice is obvious because a higher temperature will necessarily lead to a shorter oxidation time, as taught by Chau and one of ordinary skill would be motivated to use such higher temperature (e.g. up to 950 °C) and shorter time (e.g. 20 to 60 sec) to reduce the time required to form the gate dielectric. Further in this regard, there exists no

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evidence of record that the time is critical to the practice of the invention. (See *In re Aller*, above.)

6. Claim 42 is rejected under 35 U.S.C. 103(a) as being unpatentable over US 6,066,581 (**Chivukula et al.**) in view of the excerpt from the basic textbook of **Van Zant**, Microchip Fabrication, A Practical Guide to Semiconductor Processing, 3rd ed. McGraw-Hill: New York, 1997, pp. 157-160.

Chivukula discloses a method of fabricating a semiconductor device comprising the steps of

depositing a dielectric film (specifically PZT, a ferroelectric film which inherently has a dielectric constant of at least 25) over a semiconductor substrate to form a capacitor dielectric; and

subjecting the dielectric film to a wet oxidation with steam process using a mixture comprising water, oxygen, and optionally ozone at a temperature of 450 °C to 800 °C in a rapid thermal annealing (RTA) chamber for 30 seconds to several minutes to form uniform grain sizes in the ferroelectric material in a shorter time, at reduced temperature and superior characteristics during high frequency use compared to using dry oxidation and which inherently raises the oxygen content of the dielectric film (column 14, lines 27-48). (See also col. 12, lines 12-38 and col. 13, lines 5-53. See MPEP 2112.)

Chivukula does not teach that the water is provided by reacting hydrogen and oxygen to produce steam, but does teach that

“Water vapour was conveniently introduced into the annealing atmosphere of the rapid thermal anneal (RTA) system during the annealing of the PZT

by passing oxygen (O₂) through a double bubbler containing purified deionized water, so that the oxygen was saturated with water vapour, e.g. using a gas flow rate of about 2 L/min." (Chivukula, col. 13, lines 40-46).

Van Zant teaches that "Dryox," a mixture of hydrogen and oxygen gases which react to form a steam oxidizing mixture in the reactor, is preferred over liquid systems such as a bubbler, because the process is cleaner and more controllable and also that "Dryox is the preferred method for production of advanced devices." (See pp. 157-160 -- especially page 160.)

It would have been obvious to one of ordinary skill in the art at the time the invention was made to use hydrogen and oxygen as taught by **Van Zant** to form the steam for the wet oxidation mixture of **Chivukula**, for the reasons indicated in **Van Zant**, as noted and especially because "Dryox" is preferred to bubblers which **Chivukula** uses.

Furthermore, the method by which the water for the wet oxidizing atmosphere is not critical according to Applicant's admissions in the instant specification. Rather, Applicant's specification teaches away from such unexpected results. Applicant teaches,

"One of several techniques can be used to provide steam to a vicinity of the insulating film. Such techniques include using a **bubbled water vapor system**, a **pyrogenic system** or a **catalytic system**, or **generating steam in the chamber *in situ***." (Emphasis added. See instant specification, page 3, lines 13-17.)

In other words, any of the presently notoriously well-known means to form the steam, which are specifically used in the art for oxidation, could be used, according to Applicant. Also note that the paragraph bridging pages 7 and 8 of Applicant's specification indicates specifically that a bubbler can be used in the instant invention.

Then the only difference is that the ratio of hydrogen to oxygen and the pressure of 1 milliTorr is not taught in **Chivukula**. However, **Chivukula** indicates that the wet oxidation is

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carried out in water plus oxygen and ozone (**Chivukula** at col. 13, lines 36-46). “[I]n considering the disclosure of a reference, it is proper to take into account not only specific teachings of the reference but also the inferences which one skilled in the art would reasonably be expected to draw therefrom.” *In re Preda*, 401 F.2d 825, 826, 159 USPQ 342, 344 (CCPA 1968) See also *In re Lamberti*, 545 F.2d 747, 750, 192 USPQ 278, 280 (CCPA 1976). With this in mind, because **Chivukula** teaches that oxygen must be in excess of the water vapor, one of ordinary skill would know, based upon the stoichiometry of the reaction between hydrogen and oxygen to form the “Dryox” mixture containing water (as taught by **Van Zant**) that the ratio of hydrogen to oxygen must necessarily be less than or equal to about 0.67 because hydrogen reacts with oxygen in a 2 to 1 stoichiometric ratio ($2 \text{ H}_2 + \text{O}_2 \rightarrow 2 \text{ H}_2\text{O}$). Otherwise, the oxygen will be depleted in the formation of water and excess hydrogen would remain, contrary to the teaching in **Chivukula**. Accordingly, one of ordinary skill would clearly recognize that using the more desirable method of “Dryox” oxidation, as taught by **Van Zant**, would necessarily require a range hydrogen to oxygen of 0.67 or less in order to achieve the mixture taught by **Chivukula** which requires excess oxygen with the water, which overlaps the claimed ratio of 0.1 to 0.8.

Finally while the pressure of 1 milliTorr is not taught in **Chivukula**, the pressure is a matter of routine optimization. The selection of the 1 milliTorr is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species. See *In re Jones*, 162 USPQ 224 (CCPA 1955)(the selection of optimum ranges within prior art general conditions is obvious) and *In re Boesch*, 205 USPQ 215 (CCPA 1980)(discovery of optimum value of result effective variable in a known process is obvious). Currently, there exists no criticality of the pressure to the practice of the instant invention since

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pressures as low as 1 milliTorr (0.001 Torr) and about 760 Torr can be used, according to the instant specification.

7. Claims 13, 14, and 16 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Chivukula** in view of **Van Zant** and US Patent Application Publication 2002/0004248 A1 (**Lee et al.**).

In addition to the features indicated above with respect to claim 42, **Chivukula** additionally discloses subjecting the dielectric film to a densifying treatment to stabilize said dielectric film by heating the semiconductor substrate at 100 °C and then again at 350-400 °C, which removes volatile organic components prior to performing the wet oxidation on the stabilized PZT dielectric film.

Chivukula does not indicate that the PZT dielectric film is used a “part of a gate of a transistor” but does indicate that the process may be used to form ferroelectric films for semiconductor devices in general such a CMOS and RAM devices (Abstract).

Lee teaches that PZT film **130** may be used as “part of a gate of a transistor” and may be formed by a sol gel method (**Lee**; Fig. 9; paragraph [0042]).

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use the method of **Chivukula** in view of **Van Zant** to form the PZT film of **Lee** because **Lee** suggests using a sol-gel method, and the method of **Chivukula** is shown to be especially beneficial at least for forming PZT at lower temperatures than conventional methods because steam annealing is used. The use of hydrogen and oxygen to form the steam in **Chivukula** is obvious for the reasons indicated in **Van Zant**, as noted above and repeated here.

While **Chivukula** is silent to the pressure, the choice of pressure is a matter of routine optimization. The selection of the about 1 atmosphere is obvious because it is a matter of determining optimum process condition by routine experimentation with a limited number of species. See *In re Jones*, 162 USPQ 224 (CCPA 1955)(the selection of optimum ranges within prior art general conditions is obvious) and *In re Boesch*, 205 USPQ 215 (CCPA 1980)(discovery of optimum value of result effective variable in a known process is obvious). Currently, there exists no criticality of the pressure to the practice of the instant invention since pressures as low as 1 milliTorr (0.001 Torr) and about 760 Torr can be used, according to the instant specification.

8. Claims 13, 14, and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 6,136,728 (**Wang**) in view of US 6,114,258 (**Miner et al.**).

Regarding independent claim 13, **Wang** discloses a method of forming a gate dielectric layer on a substrate comprising the steps of

depositing a silicon nitride film 102 --as further limited by instant claim 17-- over an active region of a semiconductor substrate to form part of a gate of a transistor (Fig. 1; col. 3, lines 16-30);

subjecting the dielectric film to a heat treatment to stabilize said dielectric film by heating the semiconductor substrate to 800 °C in an N₂ atmosphere for 30 minutes (Fig. 1; col. 3, lines 16-30), said heating treatment inherently densifying the silicon nitride, as admitted in the instant specification at p. 12, first paragraph and Fig. 8, wherein a 750 °C anneal is used to stabilize the deposited dielectric; and

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subjecting the stabilized dielectric film to a wet oxidation with steam process **WVA** (or wet vapor anneal; Fig. 1) at temperatures greater than 450 °C (col. 5, lines 4-10).

(See also col. 5, lines 25-37.)

Wang does not teach that the steam for the wet oxidation is provided by reacting hydrogen and oxygen to produce steam or that the pressure is about 1 atmosphere. However, this feature is not enabled in the instant application.

Miner discloses a method of forming a gate dielectric layer on a substrate comprising the steps of

depositing a silicon nitride film **105** over an active region of a semiconductor substrate **100** to form part of a gate of a transistor (col. 2, lines 20-22; col. 4, lines 31-36; Figs. 1-3); and

subjecting the dielectric film to a wet oxidation with steam process to raise the oxygen content of said dielectric film, provided by heating a mixture of hydrogen and oxygen gases in a rapid thermal process chamber at a temperature greater than 450 °C, particularly 400 °C to 1200 °C (col. 8, lines 13-32) and specific examples of 600 °C (col. 9, line 35) and 950 °C (col. 8, lines 44-56) for a period of 30 to 120 seconds (Figs. 8a-8b; col. 10, lines 3-4) --as further limited by instant claim 14-- wherein said dielectric film undergoes wet oxidation with only a mixture of hydrogen and oxygen gases that form steam. The H₂ to O₂ ratio is 0.5/1 or less, for oxygen-rich mixtures (col. 8, lines 61-62), which falls within the claimed H₂ to O₂ ratio of 0.1 to 0.8. The ratio of "said mixture" (i.e. steam) relative to the other gases in the chamber overlaps the range of 0.1 to 0.5 and is therefore anticipated (col. 8, line 57 to col. 9, line 23). The pressure is potentially about atmospheric pressure at least during a detonation of the hydrogen and oxygen gases (Miner, col. 8, line 44 to line 56).

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It would have been obvious for one of ordinary skill in the art, at the time of the invention to use the wet oxidation method of silicon nitride of **Miner** to perform the wet oxidation of the silicon nitride layer of **Wang** at least because the process is faster than the furnace method used in **Wang**, and therefore beneficially reduces the thermal budget. In this regard, **Miner** teaches, "By reacting an oxygen-containing gas with a hydrogen-containing gas in the chamber or "in situ" ... the reoxidation reaction rapidly produces an oxide within an acceptable thermal budget." (See Miner col. 2, lines 46-50.)

Response to Arguments

9. Applicant's arguments with respect to claims 13, 14, 16, 17, and 42 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Erik Kielin whose telephone number is 571-272-1693. The examiner can normally be reached on 9:00 - 19:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead, Jr. can be reached on 571-272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Erik Kielin
Primary Examiner
November 18, 2004